HABITAT CAPABILITY MODEL FOR MARTEN IN SOUTHEAST ALASKA: WINTER HABITAT

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INTRODUCTION

Habitat capability models are needed for each of the management indicator species selected for use in the revision of the Tongass Land Management Plan. These models will be used to assist in the evaluation of effects of proposed land management activities on wildlife habitats and populations. The objective of this model is to estimate the capability of habitats in southeast Alaska to support populations of marten (Martes americana). The model provides an evaluation of habitat quality which is assumed to be related to long-term carrying capacity. This model was developed to evaluate the potential quality of winter habitat for marten. The winter cover requirements of this species are more restrictive than the cover requirements during other seasons of the year and availability of prey (Allen 1982). It is assumed that if adequate winter cover is available, habitat requirements throughout the balance of the year will not be limiting.

The marten is generally considered to be an inhabitant of climax forest communities throughout North America (Marshall 1951). The species prefers mature conifer or mixed forest stands although there are indications that it may be adaptable to a variety of forest habitats (Soutiere 1979). Use of habitat by marten is related to occurrence and availability of foods and to cover characteristics. Extensive old growth forests have been called the mainstay of marten populations in the Pacific states because they provide many den sites and abundant prey items (Meslow et al. 1981).

Marten have been eliminated throughout the southern and eastern portions of their original range (Strickland et al. 1982). This has been attributed to overharvesting and removal of mature forests through logging (Bergerud 1969; Dodds and Martell 1971; Strickland et al. 1982, Clark et al. 1987, Thompson 1991). Marten populations throughout southeast Alaska continue to be "reasonably dense" (Johnson 1981). However, very little is known of specific habitat associations in this area.

HABITAT USE

Food Habits

The food habits of marten have been studied extensively and are similar throughout their range, where studied (Marshall 1946; Cowan and MacKay 1950; Lensink et al. 1955; Quick 1955; Murie 1961; Weckwirth and Hawley 1962; Francis and Stephenson 1972; Goszczynski 1976; Koehler and Hornocker 1977; Campbell 1979; Soutiere 1979; Zielinski et al. 1983; Buskirk and MacDonald 1983, Thompson and Colgan 1987, Slough et al. 1989). Marten utilize food from four general categories: small mammals, birds, insects, and fruit. Marten exhibit a high diversity in their diet; changes in diet choice occur with season and abundance of prey species (Thompson and Colgan 1990).

The red-backed vole (Clethrionomys spp.) is the staple food source throughout the year but is most important during winter, where it occurs. The meadow vole (Microtus pennsylvanicus) appears to be a preferred food but may be generally unavailable to marten because their habitats do not overlap extensively. Deer mice (Peromyscus spp.) are abundant throughout marten habitat but are not well represented in food habits studies. Food habits studies have shown conflicting results concerning the use of red squirrels (Tamiasciurus hudsonicus) by marten. Several studies indicated that red squirrels are not preferred by marten. Other studies have reported that, at times, tree squirrels may be important to marten. The limited distribution of red-backed voles in southeast Alaska may result in dependence of marten on red squirrels in this area. The occurrence of birds and their eggs in the diet of marten generally increases in

June and July when they are most vulnerable to marten. Birds made up a large proportion of the year-round diet of marten studied on the Queen Charlotte Islands (Nagorsen et al. 1991) and on Vancouver Island (Nagorsen et al. 1989). Fruits and berries make up a large part of the diet of marten in late summer when they become available. An increase in the occurrence of insects in the diet of marten also takes place in the summer.

Water

The requirements of water for marten have not been directly addressed in the literature. However, some inferences may be made from other observations. Marten have been reported to immediately seek water to drink after being released from live traps (Hawley 1955; Lensink et al. 1955). The distribution of the red-backed vole, the marten's major prey item, is closely associated with the presence of free water (Gunderson 1959). Marten have also been reported to select drainages and timber stands with moist areas for hunting sites (Simon 1980). These findings tend to indicate that habitat selection by marten may be influenced by the availability of free water. This association has not been quantified. However, water is probably not limiting in the wet climate of southeast Alaska.

Cover

Habitat use by marten has been related to very specific vegetation related attributes of the landscape. Numerous studies have reported the relationship between canopy cover and habitat preferred by marten. Koehler and Hornocker (1977) indicated that marten required at least a 30% canopy closure in Idaho. Spencer et al. (1983) reported that habitats in the northern Sierra Nevada with 40 to 60% canopy closure were preferred and that habitats with 30% or less canopy closure were avoided. The results of a study in eastern Canada indicated that marten prefer dense conifer forest in the winter with a canopy closure greater than 75% (Bateman 1986). Hargis and McCullough (1984) further indicated that marten prefer areas with 100% cover. However, marten have also been reported to avoid dense stands (i.e., >60% crown closure) because of the lack of habitat for prey in these areas (Spencer 1981).

Conversely, marten avoid open habitats without tree canopy cover even though these areas often provide habitat for their preferred prey species (i.e., meadow vole) (Hawley and Newby 1957; Martell and Radvaryi 1977; Spencer 1981; Douglass et al. 1983). Spencer et al. (1983) reported that marten rarely went more than 30 feet (10 m) into treeless meadows. Ingram (1973) and Simon (1980) indicated that marten seldom penetrate more than 100 feet (30 m) into openings. Hargis and McCullough's (1984) observations indicated that marten would directly cross openings up to 160 feet (50 m) in width, but that they would not stop to rest or hunt. Openings up to 440 feet (135 m) across were traversed by martens if scattered islands of trees were available. Similar observations were reported by Koehler and Hornocker (1977), Spencer (1981), and Bateman (1986). They observed marten crossing clearcuts up to 330 feet (100 m) across with scattered trees and treeless openings up to 200 feet (60 m) across. Soutiere (1979) and Pulliainen (1981) both indicated that marten occasionally crossed openings up to 670 feet (200 m) across. Avoiding openings and traveling under the tree canopy may minimize the risk of predation for marten (Herman and Fuller 1974; Pulliainen 1981). It has also been suggested that deep snow in openings in winter may preclude successful hunting by marten (Koehler and Hornocker 1977; Soutiere 1979). The dense growth in clearcut openings in the summer may also hinder the marten's visual contact with prey and also provide escape cover for prey species, thus reducing foraging efficiency for marten (Steventon and Major 1982).

Special Habitat Characteristics

Snags are important to marten to provide dens for resting in both winter and and summer (Spencer 1987). Marten utilize the tops of broken snags as resting sites in the summer and cavities in snags in the winter and summer (Campbell 1979; Wynne and Sherburne 1984, Marten and Barrett 1991). The presence of snags is so critical to the well being of marten that Schmidt (1943) and Bergerud (1969) indicated that den site availability may limit marten populations. Marten tend to utilize large diameter, highly decayed snags as den sites (Campbell 1979; Spencer 1981). Preferred snags have been reported to range from 16 to 58 inches (40 to 147 cm) diameter at breast height (dbh) (Cambell 1979; Simon 1980; Spencer et al. 1983; Wynne and Sherburne 1984;

Spencer 1987). All snags known to be used by marten during one study were sheltered, at least partially, by the overstory canopy (Simon 1980).

During periods of snow cover marten forage for prey almost exclusively under the snow where this aspect of their life history was studied (Murie 1961; Zielinski 1981; Buskirk 1983). They utilize down woody material extending above the snow to gain access to prey under the snow (Hargis and McCullough 1984). Many of the marten's preferred prey species also depend upon downed wood for food storage locations and den sites (Maser et al. 1979). Marten also use down logs and other woody debris covered by snow as resting sites during winter (Capbbell 1979, Spencer 1987). These resting sites may provide the best thermal cover and the greatest protection against energy loss for marten in the winter (Buskirk et al. 1989). Marten avoid areas with little or no down woody material whether or not other cover requirements are met (Simon 1980). Dead and declining trees are therefore a necessary component of productive marten habitat (Wynne and Sherburne 1984).

Although marten can effectively use down woody material to forage under snow, the greater the depth of snow the more difficult it will be for marten to obtain food. At high elevations in southeast Alaska (i.e., >1,500 feet [460 m]) excessive snow depth may preclude marten activity. The high moisture content of snow in southern southeast Alaska may also reduce or preclude foraging under the snow. Habitat suitability may, therefore, decrease as elevation increases.

Interspersion of Habitats

Habitat selection by marten is driven by optimization of foraging success and minimization of danger and discomfort (Spencer 1981). Habitat of high quality for marten is a mosaic of plant communities (Buskirk 1983). This mosaic is best provided by uneven aged forests with an interspersion of patches of old growth trees and small openings. Such forests provide habitat for prey species and the protective cover that is important for marten.

HABITAT MODEL

The distribution and abundance of marten are determined to a large extent by the availability of cover and the presence of prey species (Simon 1980). A critical component of cover for marten, described by a number of studies, is canopy cover. Marten prefer habitats with canopies apparently for predator avoidance and other survival benefits. However, complete canopy closure results in a depletion of habitat for the marten's preferred prey species. The minimum canopy closure suitable for marten appears to be 30% (Koehler and Hornocker 1977). Optimum canopy closure ranges from 60% to 80% (Spencer et al. 1983; Bateman 1986). As canopy closure approaches 100% the value of marten habitat declines (Spencer 1981; Spencer et al. 1983). Measurements of overstory canopy closure are often not available, so alternate variables are necessary to express this relationship. A significant positive relationship has been demonstrated between canopy closure and timber volume ($r=0.81$, $P < 0.01$) based on data provided in Martin et al. (1985).

A number of studies have described the relationship between high quality marten habitat and the presence of snags (e.g., Simon 1980; Spencer et al. 1983; Wynne and Sherburne 1984; Spencer 1987). Snags typically used by marten as resting and den sites have a large diameter, often have a broken top, and are sheltered by the overstory canopy. Noble and Harrington (1981) completed an extensive survey of snag characteristics on Prince of Wales Island in southern southeast Alaska. Information from that survey indicates that stands of commercial forest (i.e., hemlock, spruce, hemlock/spruce) have higher densities of snags preferred by marten than other forest stands (i.e., noncommercial forest, muskeg forest).

Another important component of marten habitat that has been identified by numerous studies is dead and down woody material (e.g., Simon 1980; Steventon and Major 1982; Spencer et al. 1983; Hargis and McCullough 1984; Spencer 1987). Marten utilize dead and down material to gain access to prey under the snow and for den sites. Stand surveys completed in southeast Alaska currently do not provide information on density or presence of dead and down material. However, Brown and See (1981) have demonstrated a relationship between amount of dead and down material and productivity of a site. Their findings indicate that deposition of downed dead woody material generally increases with an increase in site productivity (i.e., the more productive sites grow more woody biomass for accumulation as downed woody material). Site index is also related to the volume of timber a stand produces (i.e., higher volume classes occur on areas with higher site index).

Timber volume classes may, therefore, be used to indicate degree of canopy closure, availability of suitable snags, and the presence of dead and down material in old growth forests and their associated value as habitat for marten (Table 1).

Stand age, as represented by stand size class, also has a significant effect on the suitability of habitat for marten. Marten were found to be more common in uncut areas than in younger stands in a 6-year study in Ontario (Thompson et al. 1989). All individuals observed in a study of transplanted marten in the Yukon Territory showed an affinity for late seral or climax conifer forests (Slough 1989). A portion of this effect is related to the development of canopy cover. Canopy development can be predicted, to an extent, from the age of a stand on highly productive sites (Alaback 1984). Numerous studies have shown that clearcutting is detrimental to marten populations (de Vos 1951, 1952; Grakou 1972; Steventon and Major 1982; Snyder and Bissonette 1987,). Clearcutting lowers the carrying capacity of an area for marten, resulting in larger home range sizes and lower population densities (Soutiere 1979; Thompson and Colgan 1987a, 1987b). Thompson (1988) also indicated that marten densities were 67-90% lower in logged areas up to 40 years after logging than in old growth forests. This results from an elimination of resting sites, winter hunting sites, overhead cover, and preferred prey species (Campbell 1979). Red-backed voles, the staple food source of martens in areas where these voles are present, are abundant in undisturbed forests, avoid forest openings, and are rare or absent for at least 10 years following clearcutting (Miller and Getz 1972; Powell 1972; Martell and Radvaryi 1977; Campbell 1979). Red squirrels appear to follow similar trends (Wolff and Zasada 1975; Medin 1986). Populations of small mammals not preferred by marten (e.g., deer mice) generally increase in clearcut areas (Tevis 1956a; Campbell 1979; Van Horne 1981). Clearcuts and early successional stages may receive some use by marten during snow-free periods (Koehler and Hornocker 1977, Soutiere 1979, Steventon and Major 1982). However, marten require mature and old growth forest stands during winter to provide prey and rest sites (Koehler and Hornocker 1979, Buskirk et al. 1989, Koehler et al. 1990). These factors indicate that the suitability of clearcuts as marten habitat is low (Table 2). It is assummed that some habitat value for marten is retained in clearcuts in that residual slash provides overhead cover and some less-preferred prey species are available. However, preliminary results of research on marten in southeast Alaska indicate that use of clearcuts by marten is very limited in this area (Flynn 1991).

The dense overstory that develops at approximately age 25 and persists until the next rotation at age 100 decreases the amount of light that reaches the forest floor and results in a rapid depletion of the understory vegetation. Understory vegetation provides habitat for the primary prey species of the marten. Reduction in prey populations in second growth stands results in significant reductions of marten populations (de Vos 1952, Koehler et al. 1975, Koehler et al. 1990) (Table 2).

Habitats within the beach fringe (i.e., 500 ft [150 m] of the beach) and to some extent within riparian zones are assummed to have higher value for marten than upland habitats. Several studies have shown marten to be attracted to riparian habitats (Simon 1980, Spencer et al. 1983, Hargis and McCullough 1984). The presence of 1) marine and aquatic organisms as a food source, 2) undercut banks for dens and burrows, 3) a deciduous tree layer, grasses, and sedges as habitat for prey species (Tevis 1956b, Ream and Gruell 1979), and 4) increased dead and down material resulting from blowdown (Buskirk et al. 1989) are assumed to make these habitats more valuable for marten (Table 3).

Availability of prey items for marten may decrease as snow depth increases, especially with elevation. Elevation, therefore, is assumed to influence the quality of habitat for marten (Table 4).

Timber harvest and other resource development activities require the construction of roads. These roads provide additional access for trappers which usually results in increased harvests of marten. Marten are easily trapped and can be overharvested, especially where trapping pressure is heavy

(Strickland et al. 1982). Density of roads may affect the quality of habitat for marten through trapping, especially where there is potential of overtrapping (Thompson 1988). Mean home range sizes reported for marten throughout their range are approximately 1 mi^2 (2.6 km^2) (Strickland et al. 1982). Home ranges of males tend to be discrete but they overlap with the ranges of 1 or more females. Therefore, whenever roads are built within 2 mi (3.2 km) of the beach or built less than 2 mi (3.2 km) apart a high risk exists that unregulated trapping on these roads will result in an overharvest of resident marten. It is assumed, therefore, that as road densities exceed 0.2 mi/mi^2 densities of marten will decrease (Figure 1). As road densities approach 0.6 mi/mi^2 marten densities will be reduced by 90% due to greatly increased trapping pressure.

EQUATIONS

In order to obtain a life requisite value for marten for each habitat the individual habitat capability index values for appropriate variables must be combined. This is accomplished in this model by multiplying appropriate habitat capability index values together for a site to obtain the overall index value (Table 5).

HABITAT CAPABILITY

A mean density of 1 $marten/mi^2$ (0.39 $marten/km^2$) is assumed in southeast Alaska based on preliminary results of research on northeast Chichagof Island (Flynn 1991). This density was used to calibrate the model on a 50 mi^2 (130 km^2) area on northeast Chichagof Island. When optimum habitat (i.e., capability index = 1.0) was assumed to support a population of 2.71 $marten/mi^2$ (1.05 $marten/km^2$) the model projected an approximate overall density of 1 $marten/mi^2$ (0.39 $marten/km^2$). Density of marten in optimum habitats is therefore assumed to be 2.71 $marten/mi^2$ (1.05 $marten/km^2$) (Table 5).

VERIFICATION

Model verification is intended to only ensure that the model provides reasonable results and behaves as intended. Additional evaluation, through field experiments, will be necessary to test the validity of model results against information from the real system and to examine the validity of assumptions made in the model.

The appropriateness of this model was verified by comparing the capability indices developed from information in the literature with preliminary marten habitat use/availability data from northeast Chichagof Island (Flynn 1991) (Table 6). This comparison shows a strong correlation between model indices and actual habitat selection indices ($r = 0.97$) indicating that the model approximates natural systems and can be used with some confidence.

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LITERATURE CITED

Alaback, P. B. 1984. Plant succession following logging in the Sitka spruce-western hemlock forests of southeast Alaska: Implications for management. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. PNW-173. 26pp.

Allen, A. W. 1982. Habitat suitability index models: marten. U.S. Dep. Inter. Fish and Wildl. Serv. FWS/OBS-82/10.11. 9pp.

Bateman, M. C. 1986. Winter habitat use, food habits and home range size of the marten, Martes americana, in western Newfoundland. Can. Field-Nat. 100:58-62.

Bergerud, A.. 1969. The status of pine marten in Newfoundland. Can. Field-Nat. 83:128-131.

Brown, J. K. and T. E. See. 1981. Downed dead woody fuel and biomass in the northern Rocky Mountains. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. INT-117. 48pp.

Buskirk, S. W. 1983. The ecology of marten in southcentral Alaska. Ph.D. thesis. Univ. Alaska, Fairbanks. 131pp.

_____, S. C. Forrest, M. G. Raphael, and H. J. Harlow. 1989. Winter resting site ecology of marten in the central Rocky Mountains. J. Wildl. Manage. 53:191-196.

_____, and S. O. MacDonald. 1984. Seasonal food habits of marten in south-central Alaska. Can. J. Zool. 62:944-950.

Campbell, T. M., III. 1979. Short-term effects of timber harvests on pine marten ecology. M.S. Thesis. Colorado State Univ., Ft. Collins. 71pp.

Clark, T. W., E. Anderson, C. Douglas, and M. Strickland. 1987. Martes americana. Mamm. Species 289:1-8.

Cowan, I. M. and R. H. MacKay. 1950. Food habits of the marten (Martes americana) in the Rocky Mountain region of Canada. Can. Field-Nat. 64:100-104.

de Vos, A. 1951. Recent findings in fisher and marten ecology and management. Trans. North Am. Wildl. Conf. 16:498-505.

de Vos, A. 1952. Ecology and management of fisher and marten in Ontario. Tech. Bull. Ont. Dep. Lands, For., and Wildl. Ser. 1. 90pp.

Dodds, D. G. and A. M. Martell. 1971. The recent status of the marten (Martes americana americana) in Nova Scotia. Can. Field-Nat. 85:61-62.

Douglass, R. J., L. G. Fisher, and M. Mair. 1983. Habitat selection and food habits of marten, Martes americana, in the Northwest Territories. Can. Field-Nat. 97:71-74.

Flynn, R. 1991. Ecology of martens in southeast Alaska. Alas. Dep. Fish and Game, Fed. Aid in Wildl. Rest., Res. Proj. Rep., Proj. W-23-4, Study 7.16. Juneau. 33pp.

Francis, G. R. and A. B. Stephenson. 1972. Marten ranges and food habits in Algonquin Provincial Park, Ontario. Ont. Minist. Nat. Resour. Res. Rep. (Wildl.) 91. 53pp.

Goszczynski, J. 1976. Composition of the food of martens. Acta Theriol. 21:527-534.

Gunderson, H. L. 1959. Red-backed vole habitat studies in central Minnesota. J. Mammal. 40:405-412.

Hargis, C. D. and D. R. McCullough. 1984. Winter diet and habitat selection of marten in Yosemite National Park. J. Wildl. Manage. 48:140-146.

Hawley, V. D. 1955. The ecology of the marten in Glacier National Park. M.S. Thesis. Univ. Montana, Missoula. 131pp.

Hawley, V. D. and F. E. Newby. 1957. Marten home ranges and population fluctuations. J. Mammal. 38:174-184.

Herman, T. and K. Fuller. 1974. Observations of the marten, Martes americana, in the Mackenzie district, Northwest Territories. Can. Field-Nat. 88:501-503.

Ingram, R. 1973. Wolverine, fisher, and marten in central Oregon. Oreg. State Game Comm., Central Reg. Admin. Rep. 73-2. 41pp.

Johnson, L. 1981. Otter and marten life history studies. Alas. Dep. Fish and Game. Fed. Aid in Wildl. Rest., Final Rep., Proj. W-17-10,11 and W-21-1, Job 7.10R. Juneau. 29pp.

Koehler, G. M., J. A. Blakesley, and T. W. Koehler. 1990. Marten use of successional forest stages during winter in north-central Washington. Northwest Nat. 71:1-4.

_____, and M. G. Hornocker. 1977. Fire effects on marten habitat in the Selway-Bitterroot Wilderness. J. Wildl. Manage. 41:500-505.

_____, W. R. Moore, and A. R. Taylor. 1975. Preserving the pine marten: management guidelines for western forests. West. Wildlands. 2:31-36.

Lensink, C. J., R. O. Skoog, and J. L. Buckley. 1955. Food habits of marten in interior Alaska and their significance. J. Wildl. Manage. 19:364-368.

Marshall, W. H. 1946. Winter food habits of the pine marten in Montana. J. Mammal. 27:83-84.

_____. 1951. Pine marten as a forest product. J. For. 49:899-905.

Martell, A. M. and A. Radvanyi. 1977. Changes in small mammal populations after clearcutting of northern Ontario black spruce forest. Can. Field-Nat. 91:41-46.

Martin, J. R., W. W. Brady, and J. M. Downs. 1985. Preliminary forest plant associations (habitat types) of southeast Alaska: Chatham Area, Tongass National Forest (draft). U.S. Dep. Agric. For. Serv., Tongass Natl. For., Sitka, Alas. 91pp.

Martin, S. K. and R. H. Barrett. 1991. Resting site selection by marten at Sagehen Creek, California. Northwest. Nat. 72:37-42.

Maser, C., R. G. Anderson, K. Cromack, Jr., J. T. Williams, and R. E. Martin. 1979. Dead and down woody material. Pages 78-95 in J. W. Thomas, tech. ed. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. U.S. Dep. Agric. For. Serv. Handbk. 553.

Medin, D. E. 1986. The impact of logging on red squirrels in an Idaho conifer forest. West. J. Appl. For. 1:73-76.

Meslow, C. E., C. Maser, and J. Verner. 1981. Old-growth forests as wildlife habitat. Trans. North Am. Wildl. Nat. Resour. Conf. 46:329-335.

Miller, D. H. and L. L. Getz. 1972. Factors influencing the local distribution of the red-backed vole, Clethrionomys gapperi, in New England. Univ. Conn. Occas. Pap. Biol. Sci. Ser. 2:115-138.

Murie, A. 1961. Some food habits of the marten. J. Mammal. 42:516-521.

Newby, F. E. 1951. Ecology of the marten in the Twin Lakes area, Chelan County, Washington. M.S. Thesis. Washington State Univ., Pullman. 38pp.

Nagorsen, D. W., K. F. Morrison, and J. E. Forsberg. 1989. Winter diet of Vancouver Island marten (Martes americana). Can. J. Zool. 67:1394-1400.

_____, R. W. Campbell, and G. R. Giannico. 1991. Winter food habits of marten, Martes americana, on the Queen Charlotte Islands. Can. Field-Nat. 105:55-59.

Noble, R. E. and P. Harrington. 1981. Snag characteristics in old-growth forests on Prince of Wales Island, Alaska. U.S. Dep. Agric. For. Serv., Alas. Reg. Rep. 125., Juneau. 88pp.

Powell, R. A. 1972. A comparison of populations of boreal red-backed voles (Clethrionomys gapperi) in tornado blowdown and standing forest. Can. Field-Nat. 86:377-379.

Pulliainen, E. 1981. Winter habitat selection, home range, and movements of the pine marten (Martes martes) in a Finnish Lapland forest. Pages 1068-1087 in J.A. Chapman and D. Pursley, eds. Proc. Worldwide Furbearer Conf., Frostburg, Md.

Quick, H. F. 1955. Food habits of marten (Martes americana) in northern British Columbia. Can. Field-Nat. 69:144-147.

_____. 1956. Effects of exploitation on a marten population. J. Wildl. Manage. 20:267-274.

Schmidt, F. 1943. Natural history of the spruce and stone marten. in Monographs on the wild mammals. Vol. 10. Inst. Jagdkunde Univ. of Gottingen. Germany.

Simon, T. L. 1980. An ecological study of the marten in the Tahoe National Forest, California. M.S. Thesis. Calif. State Univ., Sacramento. 187pp.

Slough, B. G. 1989. Movements and habitat use by transplanted marten in the Yukon Territory. J. Wildl. Manage. 53:991-997.

_____, W. R. Archibald, S. S. Beare, and R. H. Jessup. 1989. Food habits of martens, Martes americana, in the south-central Yukon Territory. Can. Field-Nat. 103:18-22.

Snyder, J. E. and J. A. Bissonette. 1987. Marten use of clear-cuttings and residual forest stands in western Newfoundland. Can. J. Zool. 65:169-174.

Soutiere, E. C. 1979. Effects of timber harvesting on marten in Maine. J. Wildl. Manage. 43:850-860.

Spencer, W. D. 1981. Pine marten habitat preferences at Sagehen Creek, California. M.S. Thesis. Univ. Calif., Berkeley. 121pp.

_____. 1987. Seasonal rest-site preferences of pine martens in the northern Sierra Nevada. J. Wildl. Manage. 51:616-621.

_____, R. H. Barrett, and W. J. Zielinski. 1983. Marten habitat preferences in the northern Sierra Nevada. J. Wildl. Manage. 47:1181-1186.

Steventon, J. D. and J. T. Major. 1982. Marten use of habitat in a commercially clear-cut forest. J. Wildl. Manage. 46:175-182.

Strickland, M. A., C. W. Douglas, M. Novak, and N. P. Hunziger. 1982. Marten. Pages 599-612 in J. A. Chapman and G. A. Feldhamer. eds. Wild mammals of North America. The John Hopkins Univ. Press. Baltimore, Md.

Tevis, L., Jr. 1956a. Responses of small mammal populations to logging of Douglas-fir. J. Mammal. 37:189-196.

_____. 1956b. Effect of a slash burn on forest mice. J. Wildl. Manage. 20: 405-409.

Thompson, I. D. 1988. Habitat needs of furbearers in relation to logging in boreal Ontario. For. Chron. 64:251-261.

_____. 1991. Could marten become the spotted owl of eastern Canada? For. Chron. 67:136-140.

_____, and P. W. Colgan. 1987a. Numerical responses of martens to a food shortage in northcentral Ontario. J. Wildl. Manage. 51:824-835.

_____, and _____. 1987b. Effects of logging on home range characteristics and hunting activity of marten. in B. Bobek, ed. Proc. 18th Intern. Union. Game Biol. Conf., Krakow, Poland.

_____, I. J. Davidson, S. O'Donnell, and F. Brazeau. 1989. Use of track transects to measure the relative occurrence of some boreal mammals in uncut forest and regeneration stands. Can. J. Zool. 67:1816-1823.

_____, and _____. 1990. Prey choice by marten during a decline in prey abundance. Oecologia 83:443-451.

Van Horne, B. 1981. Demography of Peromyscus maniculatus populations in seral stages of coastal coniferous forest in southeast Alaska. Can. J. Zool. 59:1045-1061.

Weckwerth, R. P. and V. D. Hawley. 1962. Marten food habits and population fluctations in Montana. J. Wildl. Manage. 26:55-74.

Wolff, J. O. and J. C. Zasada. 1975. Red squirrel response to clearcut and shelterwood systems in interior Alaska. U.S. Dep. Agric. For. Serv. Res. Note PNW-255. 7pp.

Wynne, K. M. and J. A. Sherburne. 1984. Summer home range use by adult marten in northwestern Maine. Can. J. Zool. 62:941-943.

Zielinski, W. J. 1981. Food habits, activity patterns and ectoparasites of the pine marten at Sagehen Creek, California. M.S. Thesis, Univ. California, Berkeley. 121pp.

Zielinski, W. J., W. D. Spencer, and R. H. Barrett. 1983. Relationship between food habits and activity patterns of pine martens. J. Mammal. 64:387-396.

Table 1. Classes of timber volume in old growth forests in southeast Alaska and associated habitat capability indices for marten.

Range of Timber Volume (bf/acre)	Volume Class	Habitat Suitability Indices
<8,000	3 (i.e., noncommercial forest)	0.3
8-20,000	4	0.7
20-30,000	5	0.9
>30,000	6+	1.0

Table 2. Description of stand size classes (i.e., stand age) for forests in southeast Alaska and associated habitat capability indices for marten.

Stand Size Class	Description	Habitat Capability Index
Seedling or Sapling	Trees <5 in (13 cm) dbh	0.2
Poletimber	Trees >5 in (13 cm) dbh, <9 in (23 cm) dbh	0.1
Young growth sawtimber	Trees >9 in (23 cm) dbh, <150 years old	0.1

Table 3. Suitability of beach fringe[a] and riparian areas as habitat for marten.

Physiographic Area	Habitat Capability Index
Beach fringe	1.0
Riparian	1.0
Upland	0.9

[a]Beach fringe habitats are those within 500 ft (150 m) of the mean high tide line.

Table 4. The effect of elevation on the suitability of habitats for marten in southeast Alaska.

Elevation	Habitat Capability Index
<800 ft (245 m)	1.0
800-1500 ft (245-560 m)	0.6
>1500 ft (560 m)	0.0

Table 5. Capability of habitats in southeast Alaska to support marten[a].

Winter Habitat	Elevation							
	<800 ft (245m)				800-1500 ft (245-560 m)		>1500 ft (560 m)	
	Beach/Riparian		Upland					
	Index	#/sq mi	Index	#/sq mi	Index	#/sq mi	Index	#/sq mi
Seedling or sapling	0.20	0.54	0.18	0.49	0.12	0.33	0.00	0.00
Poletimber	0.10	0.27	0.09	0.24	0.06	0.16	0.00	0.00
Young growth sawtimber	0.10	0.27	0.09	0.24	0.06	0.16	0.00	0.00
Old growth								
Noncommercial forest	0.30	0.81	0.27	0.73	0.14[b]	0.38	0.00	0.00
Volume class 4	0.70	1.90	0.63	1.71	0.43	1.17	0.00	0.00
Volume class 5	0.90	2.44	0.81	2.20	0.54	1.46	0.00	0.00
Volume class 6+	1.00	2.71	0.90	2.44	0.60	1.63	0.00	0.00
Nonforest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

[a]Table entries under Index are the products of the individual suitability index values for the habitat components listed in Tables 1-4.

[b]The value for noncommercial forest between 800 and 1500 ft (245 and 560 m) was considered to be lower than the products indicated because of the accumulation of snow at this elevation and the lack of down and dead woody material.

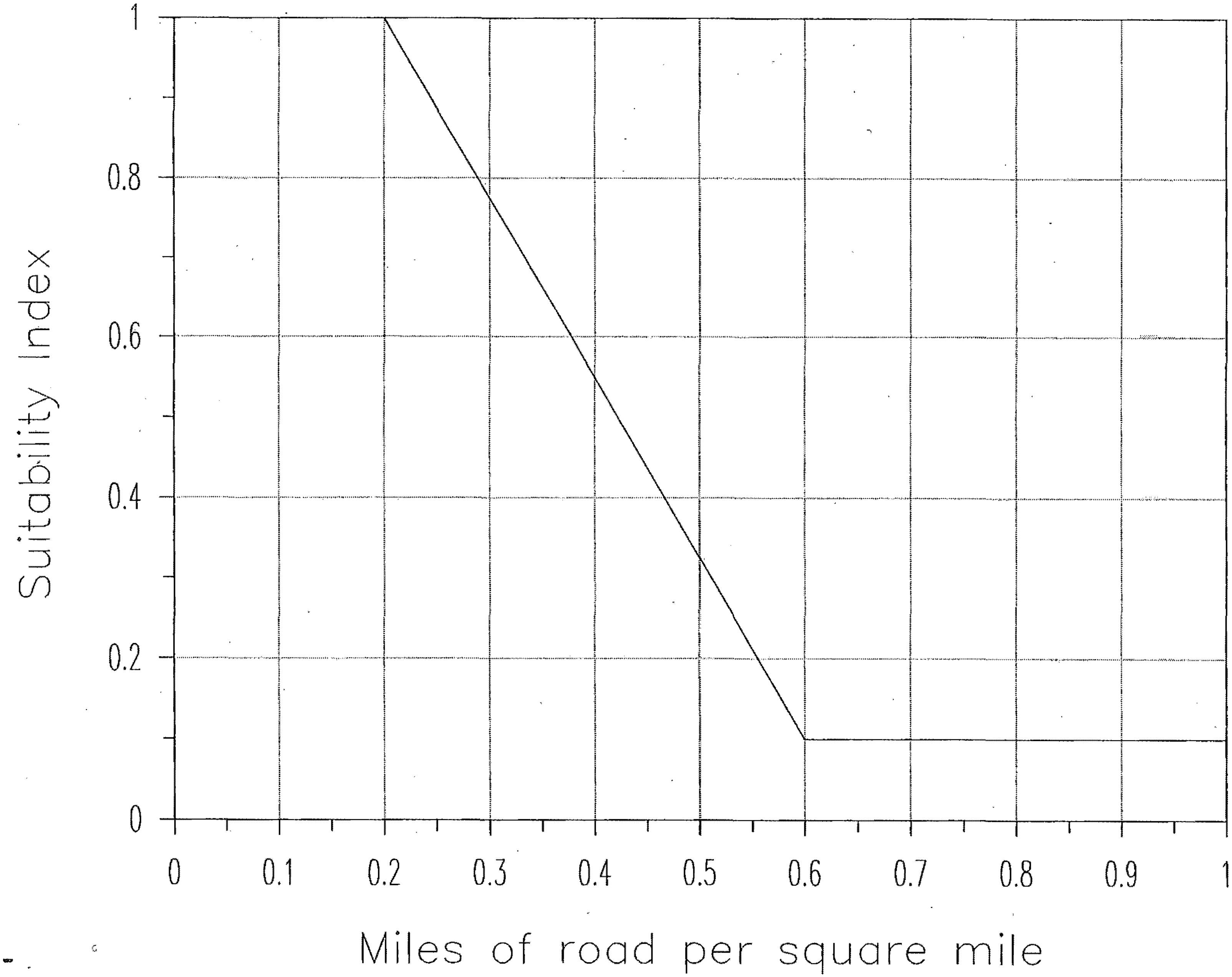
Table 6. Comparison of model habitat capability index values and habitat selection indices for marten in southeast Alaska.

Habitat	Model Habitat Capability Index Value[a]	Habitat Selection Index Value[b]
Seedling or sapling	0.20	0.00
Poletimber	0.10	--
Young growth sawtimber	0.10	--
Old growth		
Noncommercial forest	0.30	0.41
Volume class 4	0.70	0.77
Volume class 5	0.90	0.86
Volume class 6+	1.00	1.00
Nonforest	0.00	0.00

[a] Values from Table 5.

[b] Values from Flynn (1991).

List of Figures



Suitability Index
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Miles of road per square mile

APPENDICES

APPENDIX J1. Information required from the Geographic Information System to model habitat capability for marten in southeast Alaska.

Map Layer / Components	Description
Vegetation	
Forested/nonforested	Forested land has at least 10% stocking by trees of any size
Productive/unproductive	Productive forest land is capable of producing more than 240 bd. ft/ac annual growth of industrial wood
Successional stage	
Clearcut	Harvested within last 5 years or nonstocked because of harvest
Seedling/sapling	0 to 5 in diameter at breast height (DBH)
Pole timber	5 to 11 in DBH
Young growth sawtimber	11+ in DBH and less than 150 years old
Old growth	11+ in DBH and 150+ years old
Timber volume classes	
Noncommercial forest	0 - 8,000 boardfeet/acre
Low-volume old growth	8 - 20,000 boardfeet/acre
Mid-volume old growth	20 - 30,000 boardfeet/acre
High-volume old growth	30,000 + boardfeet/acre
Beach fringe	500 ft buffer from mean-high tide line
Estuary fringe	1000 ft buffer from mean-high tide line
Stream channel type	
Riparian	Within 300 ft of streams without riparian soils

APPENDIX J1. Information required from the Geographic Information System to model habitat capability for marten in southeast Alaska - continued.

Map Layer Components	Description
Soil polygons	
Riparian	Riparian soils
Topographic	
Elevation	0 - 800 ft 801 - 1500 ft >1500 ft

APPENDIX J2

INFO Program for Running the Marten Habitat Capability Model on the Tongass National Forest Geographic Information System Database.

```
/*===================================================================
/*                  USDA TONGASS NATIONAL FOREST
/*                      IDT STREET PROGRAMMING
/*===================================================================
/* Macro Name:  MAAM.AML
/* Authors: Lowell H. Suring, Gene Degayner and Rick Griffen
/*       USDA Forest Service, Alaska Region and Tongass National Forest
/*
/* Modified by L.H. Suring to update the density calculations.
/*
/* Date: 28 February 1991
/*-------------------------------------------------------------------
/* Purpose:  This macros determines the HSI values for marten.
/*  An Info program called MAAMHSI.PRG is created, which actually runs
/*  the model and calculates the HSI values for the grid points.
/*===================================================================
/* Input:  Quad Name
/*
/*===================================================================
/* Output:  MAAMHSI.PRG and MAAMOCC.PRG in INFO, and MAAMHSI values in
/*          the MAAM.DATA file.
/*
/*===================================================================
/*
&Args cover

/* Check for existence of cover

&IF ^ [EXISTS %COVER% -COVER] &THEN
 &RETURN &INFORM %COVER% DOES NOT EXIST IN THIS WORKSPACE

/* Check for existence of Marten lookup table, if present kill it!

&IF [EXISTS MAAM.DATA -INFO] &THEN
 &DATA ARC INFO
  SEL MAAM.DATA
  ERA MAAM.DATA
  Y
  Q STOP
 &END

PULLITEMS %COVER%.PAT MAAM.DATA
AREA
PERIMETER
%COVER%#
%COVER%-ID
ACRES
OWNER
VCU
```

```
SSIZEC
FTYPE
FPROD
CNS
CT
ELEV-RNG
ESTUARY
FISH-HAB
BEACH
VOLC
END

ADDITEM MAAM.DATA MAAM.DATA MAAMPOP  4 9 B 3
ADDITEM MAAM.DATA MAAM.DATA MAAMHSI 4 4 F 2

&If  [Exists MAAM.DATA -Info] &Then
 &DO
  &SYS DEL/2=IGN ^MARTEN_FILE_EXISTS_4_%COVER%
  &SYS CRE  ^MARTEN_FILE_EXISTS_4_%COVER%
 &END

/*
/*  This first section sets up the relate environment for the programs.
/*
&Data Arc Info
SEL MAAMOCC.PRG
ERA MAAMOCC.PRG
Y
SEL MIS_OCCUR.LUT
ERA MIS_OCCUR.LUT
Y
ADIR :STAFF:GIS:TNF:TABLES:INFO
TAKE FROM DATA ARC MIS_OCCUR.LUT
ADIR :INFOSYS
SEL MAAM.DATA

RELATE MIS_OCCUR.LUT 1 BY VCU ORDERED
REM
REM PROGRAM MAAMOCC.PRG
REM RESELECT $1MAAM = 1
REM IF $NOSEL = 0
REM  OUTPUT ^NO_MARTEN_IN_RESQ INIT
REM ENDIF
REM END

REM RUN MAAMOCC.PRG
REM ERA MAAMOCC.PRG
REM Y
REM Q STOP
REM &END
/*
/*  If the previous program did not find marten
/*  on the whole quad, the macro will not run the modelling portion.
/*
```

```
/* &If [Exists NO_MARTEN_IN_%COVER% -FILE] &Then
/* &Return &Inform  *** Marten do not occur on %COVER%. ***
/*
ERA MAAMHSI.PRG
Y
PROGRAM MAAMHSI.PRG
REM
REM  This program calculates habitat suitability index (HSI) values
REM  for marten using habitat information available in the
REM  geographic information system (GIS) developed for the Tongass
REM  Tongass National Forest.  The HSI item is assummed to be 0
REM  unless otherwise specified.  Names of the
REM  variables are consistent with those in the forest-wide GIS Data
REM  Dictionary, or in the grid summary files.
REM
REM  This section determines whether marten occur on the point
REM  being analyzed, and skips to the end if they do not.
REM
PROGRAM SECTION EVEN
REM
  IF $1MAAM NE 1
    GOTO DONE
  ENDIF
REM
REM  **************************************************************
REM  *                       OLD GROWTH FOREST                    *
REM  **************************************************************
IF SSIZEC = '4'
  IF VOLC = '4'
    IF ELEV-RNG = 1 OR ELEV-RNG = 2
      IF ESTUARY = 1 OR FISH-HAB = 71 OR FISH-HAB = 72 OR FISH-HAB = 100
OR FISH-HAB = 200 OR FISH-HAB = 1170 OR FISH-HAB = 1270 OR BEACH = 1
        CA MAAMHSI = .7
      ELSE
        CA MAAMHSI = .63
      ENDIF
    ENDIF
    IF ELEV-RNG = 3 OR ELEV-RNG = 4
      CA MAAMHSI = .43
    ENDIF
  ENDIF
  IF VOLC = '5' OR VOLC = '6' OR VOLC = '7'
    IF ELEV-RNG = 1 OR ELEV-RNG = 2
      IF ESTUARY = 1 OR FISH-HAB = 71 OR FISH-HAB = 72 OR FISH-HAB = 100
OR FISH-HAB = 200 OR FISH-HAB = 1170 OR FISH-HAB = 1270 OR BEACH = 1
        CA MAAMHSI = 1
      ELSE
        CA MAAMHSI = .9
      ENDIF
    ENDIF
    IF ELEV-RNG = 3 OR ELEV-RNG = 4
      CA MAAMHSI = .6
    ENDIF
  ENDIF
```

```
REM
REM              *************************************
REM              * NONCOMMERCIAL FOREST - SSIZEC = 4 *
REM              *************************************
REM
  IF FTYPE NE 'S' AND FTYPE NE 'H' AND FTYPE NE 'X' AND FTYPE NE 'C'
    IF ELEV-RNG = 1 OR ELEV-RNG = 2
      IF ESTUARY = 1 OR FISH-HAB = 71 OR FISH-HAB = 72 OR FISH-HAB = 100
OR FISH-HAB = 200 OR FISH-HAB = 1170 OR FISH-HAB = 1270 OR BEACH = 1
        CA MAAMHSI = .3
      ELSE
        CA MAAMHSI = .27
      ENDIF
    ENDIF
    IF ELEV-RNG = 3 OR ELEV-RNG = 4
      CA MAAMHSI = .14
    ENDIF
  ENDIF
ENDIF
REM
REM        ********************************************************
REM        * NONCOMMERCIAL FOREST - FPROD NE ' ' AND FPROD NE '2' *
REM        ********************************************************
REM
IF FPROD NE '2' AND FPROD NE ' '
  IF ELEV-RNG = 1 OR ELEV-RNG = 2
    IF FISH-HAB = 71 OR FISH-HAB = 72 OR FISH-HAB = 100 OR FISH-HAB =
200 OR FISH-HAB = 1170 OR FISH-HAB = 1270
      CA MAAMHSI = .3
    ELSE
      CA MAAMHSI = .27
    ENDIF
    IF ESTUARY = 1 OR BEACH = 1
      CA MAAMHSI = .3
    ELSE
      CA MAAMHSI = .27
    ENDIF
  ENDIF
  IF ELEV-RNG = 3 OR ELEV-RNG = 4
    CA MAAMHSI = .14
  ENDIF
ENDIF
REM
REM  **********************************************************
REM  *                SECOND GROWTH FOREST                    *
REM  **********************************************************
REM
IF SSIZEC = '3' OR CNS = 'N' OR SSIZEC = '2'
  IF ELEV-RNG = 1 OR ELEV-RNG = 2
    IF FISH-HAB = 71 OR FISH-HAB = 72 OR FISH-HAB = 100 OR FISH-HAB =
200 OR FISH-HAB = 1170 OR FISH-HAB = 1270
      CA MAAMHSI = .1
    ELSE
      CA MAAMHSI = .09
```

```
    ENDIF
    IF ESTUARY = 1 OR BEACH = 1
      CA MAAMHSI = .1
    ELSE
      CA MAAMHSI = .09
    ENDIF
  ENDIF
  IF ELEV-RNG = 3 OR ELEV-RNG = 4
    CA MAAMHSI = .06
  ENDIF
ENDIF
REM
REM  **************************************************************
REM  *                        CLEARCUTS                           *
REM  **************************************************************
REM
IF SSIZEC = '1' OR CNS = 'X' OR CNS = 'P'
  IF ELEV-RNG = 1 OR ELEV-RNG = 2
    IF FISH-HAB = 71 OR FISH-HAB = 72 OR FISH-HAB = 100 OR FISH-HAB =
200 OR FISH-HAB = 1170 OR FISH-HAB = 1270
      CA MAAMHSI = .2
    ELSE
      CA MAAMHSI = .18
    ENDIF
    IF ESTUARY = 1 OR BEACH = 1
      CA MAAMHSI = .2
    ELSE
      CA MAAMHSI = .18
    ENDIF
  ENDIF
  IF ELEV-RNG = 3 OR ELEV-RNG = 4
    CA MAAMHSI = .12
  ENDIF
ENDIF
REM
LABEL DONE
REM
REM  The program comes directly here prior to checking the next point
REM  if marten are not present.
REM
PROGRAM SECTION ODD
END

RUN MAAMHSI.PRG
ERA MAAMHSI.PRG
Y
CA MAAMPOP = MAAMHSI * 2.71 * ( ACRES * .0015625 )
SEL MIS_OCCUR.LUT
ERA MIS_OCCUR.LUT
Y
Q STOP

&End
&Return
```

HABITAT CAPABILITY MODELS FOR WILDLIFE
IN SOUTHEAST ALASKA

Compiled
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